GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030111

Course/ Subject Name: Advanced Analytical Techniques

W.E.F. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Students should have a foundational understanding of physical, inorganic and organic chemistry.
Rationale:	This course is intended to familiarize students with various traditional and modern physicochemical methods of analysis and the development of the students' ability to the interpretation of the results obtained by various techniques.

Course Outcome:

Upon successful completion of this course, students will be able to:

No	Course Outcomes
01	Recognize fundamentals as well as recent developments in instrumental methods of analysis
02	Understand the working of instruments as well as for the development of new technologies.
03	Select the best method of sample preparation required for a particular analytical technique.
04	Spectroscopy and microscopy to identify molecular structures from their spectra and micrograms.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Theory of errors:** Sources and classification of errors.True value, Precision, accuracy, error, mean and median, spread, deviation, standard deviation, coefficient of variation, variance Statistical treatment of analytical data & presentation of result. Sampling of solids, liquids and gases. Evaluation and validation of analytical methods. Good laboratory practices.	**6**	13
2.	**Chromatographic methods**: Introduction & classification of chromatography. Theory, instrumentation & applications of the following chromatographic techniques: (i) Column chromatography (ii) TLC (iii) Paper chromatography (iv) GC (v) HPLC.	**6**	13
3.	**UV-Visible Spectroscopy**: Introduction, Theory of UV-Visible Spectroscopy & colourimetry, Beer-Lambert law, Deviation from Beer-Lambert law. **Infrared Spectroscopy**: Introduction, Infrared radiation & its interaction with organic molecules, vibrational mode of bonds, instrumentation & applications, interpretation of IR spectra. **Mass spectrometry**: Basic principles & brief outline of instrumentation. Ion formation, molecular ion, metastable ion, fragmentation process in relation to molecular structure & functional groups.	**8**	18
4.	**Thermo-gravimetric analysis:** principles and applications. **Differential scanning calorimetry**: principles and applications.	**8**	18
5.	**Analytical Techniques:** Potentiometry, ion selective electrodes. Voltametric methods, Conductometry and conductometric titration, and Coulometric methods applied to industrial analysis and air pollution observation.	**8**	18
6	**X-ray Diffraction studies**: Principles and applications **Microscopic analysis**: SEM, TEM and AFM. Working principles, applications and sample preparations	**9**	20
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	18	22	20	00	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Chemical Analysis, Modern Instrumentation Methods and Techniques, F. Rouessac, A. Rouessac, Jon Wiley & Sons Ltd, 2007.
2. Analytical Chemistry, Theoretical and Metrological Fundamentals, K. Danser, Springer, 2007.
3. Instrumental Methods of Analysis, B. K. Sharma, Goel Publishing house.
4. Elementary Organic Spectroscopy, Y.R. Sharma, S.Chand& company Ltd. New Delhi 2008
5. Spectroscopic identification of organic compounds, R.M. Silverstein, F.X. Webster, D.J. Kiemle,John Wiley & Sons Ltd, 2005

(b) Open-source software and website:

To enhance learning, students can use the following open-source software tools and websites for simulations, data analysis, and regulatory information related to hazardous waste management:

Open-Source Software

- FullProf Suite: For sample analysis using X-ray and neutron diffraction data
- VESTA: Open-source 3D visualization software
- OpenSEM: SEM image processing and automated feature detection.
- ImageJ / FIJI: SEM image processing.
- Thermoanalysis (TA): Processing and analyzing thermogravimetric data
- Spectrographer: Processing UV-Vis, IR, and other types of spectroscopic data

Websites and Resources

- NPTEL https://archive.nptel.ac.in/courses/102/107/102107028/
- NPTEL https://nptel.ac.in/courses/104104066
- NPTEL https://onlinecourses.swayam2.ac.in/ugc19_bt16/preview
- MIThttps://ocw.mit.edu/courses/18-305-advanced-analytic-methods-in-science-and-engineering-fall-2004/

Suggested Course Practical List:

1. Isolation of compound using TLC techniques.
2. Isolation of compound using paper chromatography.
3. Isolation of compound using Column Chromatography techniques.
4. Identification of functional group using FTIR.
5. Analysis of mixture using GC.
6. Analysis of the given sample using UV-Vis spectroscopy.
7. Analysis of the given sample using IR spectroscopy.
8. Determination of crystalline characteristics from the data of XRD.
9. Analysis of image from the scanning electron microscopy.
10. Analyzing the given data from TGA.
11. Sample analysis using AFM.

Major equipment: Scanning electron microscopy, Transmission electron microscopy, X-Ray diffraction**,** Gas Chromatography-Mass Spectrometry (GC-MS), TCLP Extraction Apparatus, Column chromatography apparatus, TGA apparatus, Spectrophotometer (UV-Vis) etc.,

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Chemical Storage Cabinets
2. Personal Protective Equipment (PPE)

Suggested Project List:

- Evaluation of Photodegradation of Pollutants Using UV-Vis Spectroscopy.
- Identification and Quantification of Natural Antioxidants in Food Using UV-Vis Spectroscopy.
- Spectroscopic Characterization of Vitamin A and Its Derivatives.
- Characterization of Semiconductor Materials for Photovoltaic Devices
- Determination of Lattice Strain and Crystallite Size in Materials
- Analysis of Nanomaterials Using XRD.

- Surface Morphology and Particle Size Analysis of Nanoparticles.
- Characterization of Cell Morphology for Drug Delivery Systems.
- Investigation of Surface Functionalization in Catalysts.
- Analysis of Pharmaceuticals and Active Pharmaceutical Ingredients (APIs) using HPLC.
- Detection of Contaminants in Food and Beverages using HPLC.
- Impact of Additives on Thermal Degradation of Rubber using TGA.
- Thermal Stability of Food Additives and Ingredients using TGA,
- Application of Potentiometry in Blood Gas Analysis
- Study of Redox Reactions Using Potentiometry

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